Multiple Scattering And Volume-Roughness Interactions In Sea Bed Acoustics

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LONG-TERM GOAL

The objective of this research is to improve understanding of bottom acoustic scattering at mid- and high-frequencies and to improve conventional algorithms for remote acoustic characterization of marine sediments.

OBJECTIVES

The primary scientific objective is to develop improved theoretical models for seabed scattering using approximations having a wider range of applicability than those presently available.

APPROACH

Scattering mechanisms due to volume inhomogeneities of the sediment and roughness of its surface and internal interfaces, as well as volume-roughness interactions are considered in the frame of a unified approach [1]. Average seabed parameters can be arbitrary functions of depth and are included in the zeroth-order solution for the field and Green's function. A first-order iteration of the unified integral equation gives the first-order perturbation solution in a form more convenient for describing scattering from sea beds with complex structure. A generalization for the case of stratified fluid sediments covering rough inhomogeneous elastic half-space (basement) can be done as well [1-3].

The unified integral equation method can permit in principle a rigorous consideration of scattering in the complex seabed medium with strong volume and roughness irregularities. However, because a direct numerical approach entails a large computational burden for realistic medium parameters, the main practical application of the unified approach in the near future is validation of various analytical approximate methods considering multiple scattering effects. A Cumulative Forward-scatter Single-Backscattering (CFSB) approximation [de Wolf, 1971] seems to be promising and its modification can be applicable for treating multiple scattering in sea bed sediments [4].

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WORK COMPLETED

The general first-order model developed previously has been used to analyze the frequency-angular dependencies of the scattering strength for both monostatic and bistatic cases for various seabed types at mid- and high-frequencies. Work has continued on the problem of acoustic classification of sediments, including the sensitivity to surficial properties and the signatures of sediment roughness and volume in spatial correlation of the backscattered field.

RESULTS

The first-order analysis shows a number of distinctive features in scattering that in turn can be used as classification clues for determination of various parameters of the seafloor. Additional clues are revealed from an analysis of the spatial correlation function of the scattered field that can be used for distinguishing and/or separating the volume and roughness components of scattering [5,6].

Continued model-data comparisons using data from the CBBL experiment at Key West have shown the importance of gradients of the acoustical parameters in the thin (6 cm) top layer of sediments on roughness scattering for both monostatic and bistatic configurations [7]. Also, the sensitivity of measurable scattering characteristics (e.g., the scattering strength and its angular-frequency dependencies) is shown to be extremely strong with respect to surficial parameters. Therefore, determining the parameters at the sea bed surface by various methods (including non acoustical and in situ) is critical for providing the environmental data base for underwater acoustics experiments and those parameters can be considered as classification clues for remote acoustic characterization of marine sediments.

IMPACT/APPLICATION

The models of seabed scattering developed in this research will provide a better understanding of bottom acoustic interaction at mid- and high-frequencies and can be used as a basis for improved algorithms for remote acoustic inversions for seafloor properties.

TRANSITIONS

The results of this work are being adapted in practical models for seabed scattering. For example, a high-frequency bistatic scattering model funded by the ONR Torpedo Environments Program (6.2) incorporates the elastic scattering model developed as part of this work. The correlation method for identificating and/or separating the volume and roughness components of scattering is proposed for use in ASIAEX and other ONR experiments.

RELATED PROJECTS

This research is conducted jointly with the separately funded work of D.R. Jackson and comparisons with CBBL data have been carried out in collaboration with Kevin Briggs, Kevin Williams, Chris Jones and Tim Orsi. The approaches and models developed in this research are relevant to acoustic penetration and multiple scattering issues arising within the ONR Departmental Research Initiative on high-frequency sound interaction with the seafloor.

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